2.0 BACKGROUND

The following background information provides a broad context for approaching the subject of TMDL implementation. It is intended to help local jurisdictions devise their own ways of approaching many TMDL implementation issues that cannot be anticipated by this guidance document. The background is also a prerequisite for understanding certain subjects addressed elsewhere in the document.

2.1 An Overview of the Clean Water Act Framework: Context for TMDL Implementation

The federal Clean Water Act (CWA) provides a systematic framework for managing water resources. The following outline summarizes the key elements in sequential order.

- Water Quality Standards
  - Designated Uses
  - Criteria for Meeting the Uses
  - Antidegradation Policy
- Water Quality Monitoring Strategy for State-wide Water Quality Assessment
- Data Management and Analysis
- Water Quality Reporting (Integrated 305b Report and 303d List of Impaired Waters)
- Intensive Monitoring and Information Collection to Support TMDL Development
- TMDL Development
- TMDL Implementation Planning and Execution
- Evaluation of implementation measures and the water quality response to those measures
- Continuous Planning Process (CPP)

Each element in the sequence supports the next element; for example, water quality standards indicate what to look for when conducting water quality monitoring. The public is provided an opportunity to review most steps in this sequence. This CWA framework is designed with the understanding that new insights gained at each step of the process can be used to continually improve the elements of the framework.

2.1.1 Water Quality Standards

Water quality standards address the federal requirement "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Clean Water Act §101). The broad term "water quality standards" encompasses the adoption of "designated uses" and specific "criteria" that indicate whether or not the uses are being achieved. For example, coldwater streams should support the "designated use" of naturally reproducing trout fisheries. In turn, naturally reproducing trout fisheries require that specific "criteria" be met for temperature, dissolved oxygen, physical habitat and other characteristics. This section provides basic background on water quality standards. Consult the Index for additional references to Water Quality Standards.

2.1.1.1 Designated Uses

Uses are identified by taking into consideration the use and value of the waterbody for public water supply; for protection of fish, shellfish, and wildlife; and for recreational, agricultural, industrial, and navigational purposes. Designated uses provide the foundation upon which waters of the State are managed under the Federal Clean Water Act. States and Tribes examine the suitability of a waterbody for the uses based on the physical, chemical, and biological characteristics of the waterbody, its geographical setting and scenic qualities, and economic considerations. Social preferences regarding the expectations for water quality, and trade-offs in conflicting goals, are determined through the public process of establishing designated uses. Designated uses may be goals for a waterbody, but must protect "existing uses"[1] and should be attainable. Once designated uses are established, water quality criteria are determined with sufficient coverage of parameters and of adequate stringency to ensure the protection of the designated uses. Water quality criteria are narrative or numeric expressions for pollutant thresholds not to be exceeded. Generally speaking, criteria are inviolate, meaning that, as a society, we have agreed not to violate standards regardless of implications *unless* we agree to change the underlying designated uses through an open public process, which then allows for the criteria to be changed in response (see Use Attainability Analysis below).

2.1.1.2 Antidegradation Policy

The water quality standards regulations require States to establish a three-tiered antidegradation policy. The specific steps to be followed depend upon which tier or tiers of antidegradation apply. Antidegradation implementation procedures identify the steps to take and questions that must be addressed when regulated activities are proposed that may affect water quality. Most relevant to Maryland presently are "Tier 2" waters, classified as "high quality," for which special protections are required beyond those that apply to all waters.

Tier 1 maintains and protects existing uses and water quality conditions necessary to support such uses. An existing use can be established by demonstrating that fishing, swimming, or other uses have actually occurred since November 28, 1975, or that the water quality is suitable to allow such uses to occur. Where an existing use is established, it must be protected even if it is not listed in the water quality standards as a designated use. Tier 1 requirements are applicable to all surface waters.

Tier 2 maintains and protects "high quality" waters -- waterbodies where existing conditions are better than necessary to support CWA § 101(a)(2) "fishable/swimmable" uses. Water quality may be lowered; however, State and Tribal Tier 2 programs must identify procedures to be followed and questions that must be answered before a reduction in water quality can be allowed (See COMAR 26.08.02.04 and .04-1). In no case may water quality be lowered to a level that would interfere with existing or designated uses.

Tier 3 maintains and protects water quality in outstanding national resource waters (ONRWs). Except for certain temporary changes, water quality cannot be lowered in such waters. ONRWs

[1] The uses that were actually being met in November of 1975.

generally include the highest quality waters of the United States. However, the ONRW classification also offers special protection for waters of exceptional ecological or recreational significance, *i.e.*, those that are important, unique, or sensitive ecologically or aesthetically. Decisions regarding which waterbodies qualify to be ONRWs are made by States (COMAR 26.08.02.04-2) and authorized Indian Tribes.

2.1.1.3 Use Attainability Analyses

The process of changing designated uses involves conducting a use attainability analysis (UAA). A UAA is necessary when there is significant uncertainty as to the attainability of designated uses that were previously established (remember, designated uses may be waterbody "goals", and should be attainable when established). For example, setting a goal to have aquatic life representative of a forested watershed as the desired result in an urban stream, or the goal of water quality for swimming to be available in waters highly impacted by bacteria from wildlife sources that cannot be reduced since they are naturally occurring, may not be attainable.

A UAA is "a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in 40 CFR Sec. 131.10(g)." The six factors include natural and manmade effects that may irretrievably impact the potential use attainment in a waterbody, as well as the potential for widespread social and economic impacts required to attain the standards. A UAA supports a regulatory change to remove or lower a designated use, or to designate less restrictive criteria to protect a given set of uses, and to designate the "highest attainable use", based on the results of the UAA. Since a UAA is a scientific study, any group (state or local government, developer, industry, watershed organization, *etc*.) may perform the study.

The decision to change a water quality standard based on the information contained in the UAA is a public process that is regulatory in nature, and may only be performed by the Department of the Environment. The water quality standards for these waterbodies must be re-examined every three years (normally during a Triennial Review) to determine if new information has become available that would warrant a revision of the standard. If new information indicates that designated uses, which were previously determined unattainable through the UAA process, can now be attained, such uses must be designated.

Part of the requirements of a UAA is the determination of the "highest attainable use". This is a reflection that the existing conditions observed at the time of the UAA are not acceptable, even though the designated uses, as established, are not attainable. Determining the "highest attainable use" may be accomplished through modeling the effects of implementation of permits, comparison of reference sites or maximum feasible application of Best Management Practices (BMPs). Once determined, the highest attainable use is reflected in the new water quality standards. Although lower than the original standards, meeting the newly established standards may be a long-term process. It may be desirable to develop adaptive management plans that demonstrate commitment to, and implementation of, improvements to achieve the new designated uses and criteria. The State is required to review these areas every three years at a minimum, and to upgrade water quality standards if data indicate water quality standards meeting the requirements of the CWA can be attained.

2.1.2 Water Quality Monitoring Strategy for State Assessment

The Clean Water Act requires all waters of the State to be assessed on a periodic basis. The State maintains a water quality monitoring strategy, which among other things, describes how this requirement is addressed in Maryland (MDE, 2004).

Water quality monitoring for State-wide assessment is conducted in a way that ensures the resulting data will be sufficient to assess whether or not the standards are being met[2]. For example, when monitoring coldwater streams, a number of parameters must be measured, including dissolved oxygen, temperature, pH and the biological integrity of the stream.

Consider the dissolved oxygen criteria for the naturally reproducing trout designated use. For all non-tidal waters of Maryland, regardless of whether they are trout waters, dissolved oxygen (DO) concentrations must be above 5.0 mg/l at all times (some exceptions apply for deep waters in tidal areas and impoundments). However, because trout are particularly sensitive to oxygen needs, trout waters have the additional requirement of keeping the average DO above 6.0 mg/l. This implies that, for trout waters, monitoring data must be collected in a manner that allows both of these DO thresholds to be assessed.

In summary, water quality monitoring methods are designed to reflect the needs of assessing water quality standards. Monitoring provides a foundation for the following step, the analysis of water quality data to determine if standards are being achieved.

2.1.3 Data Management and Analysis

The monitoring of water quality often entails sending samples to laboratories where they are analyzed and the results are recorded. In addition to the water quality results, this process generates vast amounts of information that supports the assurance of the data's quality. The reliable transfer and management of such data is essential due to the vital importance of this information and the expense and staffing expertise involved in performing this function.

The Maryland Department of Environment (MDE) uses the US EPA's STORET data management system for storing and reporting this information. Further discussion of this process is beyond the scope of this guidance.

2.1.4 Integrated Water Quality Assessment (Identification of Impaired Waters)

The assessment of water quality monitoring data is done according to water quality standards, *i.e.*, determining if waters of the State are meeting their designated uses. Conceptually, this involves comparing the monitoring data to criteria, like 5.0 mg/l for dissolved oxygen in non-tidal waters. However, because data cannot be collected at all times in all places, they are an imperfect representation of the real world. The State is also required to consider all readily

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[2] In some cases initial screening monitoring is conducted with the intent to perform verification monitoring if a potential violation is indicated.

available data from the previous five years, some of which might have been collected for purposes other than assessing the attainment of water quality standards.

Consequently, systematic procedures for interpreting the data have been developed and documented to ensure a consistent, reproducible process for determining whether or not a water quality standard is violated. Procedures have been developed for all major categories of media (*e.g.*, water, sediment, fish tissue) that are monitored. These procedures are subject to public review and comment during the public process for the biennial release of the "Integrated List". See Chapter 8, "Listing Methodologies," of Maryland's Integrated Water Quality Assessment report.
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/final_2004_303dlist.asp

This integrated assessment report combines a comprehensive inventory of water quality, required by Section 305(b) of the CWA, with a list of impaired waters commonly called "the 303(d) list," required by Section 303(d) of the CWA. The integrated assessment is documented in the form of a 5-part list intended to represent all possible classifications of water quality status.

Category-5 of the integrated inventory constitutes the 303(d) list of impaired waters for which TMDLs are to be developed. This list identifies the pollutant causing the impairment, and identifies priorities and scheduling information for TMDL development[3].

In summary, waters of the State are assessed by comparison of water quality data to the established water quality standards, using documented methodologies. A list of waters not achieving standards, after all required management measures are in place, is reported to the US EPA and constitutes the waters for which TMDL analyses are required (the 303(d) list).

2.1.5 TMDL Development

As noted above, the 303(d) list identifies waters that fail to meet standards even after all of the required management measures are in place. The logic of the Clean Water Act is fairly straightforward. If the required pollution management measures are in place, but the remaining pollutants still cause the water quality standards to be violated, then it is necessary to conduct a scientific study of the waterbody to determine a "pollution budget" that will meet water quality standards. This study is commonly called a "TMDL analysis," because it determines the Total Maximum Daily Load (TMDL) of the impairing pollutant that may go into the affected waterbody without causing a water quality impairment[4].

[3] To be precise, the 303(d) list of impaired waters is actually a subset of impaired waters that fail to meet standards even after all of the minimum required management measures are in place. Waters that are impaired solely because minimum management requirements are not in place are not included in the 303(d) list. Instead, these waters are listed on Part 4b of the integrated list and other actions are taken to implement required management measures.

[4] It should be noted that some water quality standards violations are not conducive to TMDL analyses in the traditional sense of setting a loading limit expressed in terms of mass per unit time. Federal regulation 40CRF 130.2 requires TMDLs to be expressed in terms of mass per unit time, toxicity or other appropriate measure. TMDLs that are not expressed in terms of mass per unit time (loads) are referred to as "Non-traditional TMDLs," (See Section 2.3.3).

That is, the essence of a TMDL analysis is to quantify the maximum amount of the impairing substance or stressor that the waterbody can assimilate without violating standards. In doing so, the TMDL analysis defines a quantified framework for TMDL implementation, discussed briefly below.

Typically the TMDL is developed using some sort of waterbody simulation. EPA has developed several programs to help states do this, and there are other programs and models available as well. Typically there are two parts to the simulation process. The first part simulates the land part of the watershed, and, based on land use, estimates the loads of a pollutant that will be delivered to the waterbody. The second part simulates what happens when the pollutant gets into the waterbody and includes transport, transformations, and losses. Results include the prediction of water quality parameters, such as dissolved oxygen or chlorophyll concentrations. Using these models to run various "scenarios," State technical staff can estimate the maximum loads of the pollutant that would result in acceptable water quality (*i.e.*, within the criteria limit).

In some cases, the stressor may not be a substance that can be expressed in traditional terms of a load (mass per unit time). An example of this situation might be a trout stream impacted by increased water temperature due to clearing of riparian buffers. This would require a non-traditional approach that expresses the TMDL in quantified terms other than a load. Recently, one of the Midwestern states approached this problem, but not through a traditional engineering expression (*i.e.*, BTU reduction per unit area); rather, they expressed the TMDL in terms of percent effective shade, a concept amenable to public communication. Implementation of this type of TMDL would require a simple calculation of required canopy cover (% effective shade) in the riparian area, as well as the number of stream miles to be replanted with buffers.

Note that the 303(d) listings identify the combination of a waterbody and a substance or stressor that is causing a standard to be violated. Thus, it is possible for a single waterbody to have multiple 303(d) listings for a number of different impairing substances, implying the potential for more than one TMDL to be required for a single waterbody.

In summary, TMDL analyses are conducted for waters identified on Maryland's 303(d) list, which identifies specific pollutants causing a particular waterbody to violate a water quality standard. The resultant TMDL is a measure of the maximum allowable amount of the pollutant that can be assimilated by the waterbody. The TMDL provides a quantified management goal that guides TMDL implementation.

2.1.6 TMDL Implementation Planning and Execution

As emphasized above, water quality standards represent the basic benchmarks that guide how pollutants entering waters of the State are managed. TMDL analyses quantify the maximum allowable amount of a given pollutant, or stressor, from all sources that may enter a particular waterbody. Taking a broad view, every action and decision intended to restore or protect water quality standards can be viewed as being part of the TMDL implementation process. This is true even if a TMDL analysis has yet to be conducted, or the benefits of the activity or decision cannot be quantified. This implies that local governments may take credit for many ongoing activities. Local governments are encouraged to begin communicating this broad view of TMDL implementation to the public.

A more narrow perspective of TMDL implementation builds upon the essence of a TMDL analysis, which is to establish a quantified framework for managing pollutants. The concept is best understood as it applies to managing pollutants from traditional point sources, like waste water treatment plants, and those from nonpoint sources that wash off the land during rain events[5]. From this perspective, the effects of management actions, typically called "Best Management Practices" (BMPs), can often be estimated in quantified terms. This perspective suggests the potential to establish accounting frameworks for managing certain pollutants. Such a quantified framework has been established for managing nutrients under the Chesapeake Bay Agreement. This topic is elaborated in Section 2.3.2 "Traditional TMDLs" and in Section 4.0 "Technical Guidance."

As discussed below in Section 2.3.3, "Non-Traditional TMDLs," it is possible that some future TMDLs will address water quality impairments in a "non-traditional" manner. Although such TMDLs would be required to identify quantified management actions, these actions would not be expressed in terms of pollutant loads, that is, mass per unit time like "pounds per year." Instead, the elements of non-traditional TMDLs could be expressed in terms of quantified stream restoration actions to address impairments revealed by biological data. For example, a stream that is biologically impaired may require a stream restoration effort to reduce the stream's hydraulic energy flow and thereby reduce erosion and sedimentation, rather than a control process such as a sewage treatment plant. This subject is still somewhat uncertain, and the State awaits policy direction from the US EPA.

In summary, local governments are advised to characterize their ongoing water pollution management activities in terms of TMDL implementation and standards attainment (including antidegradation policy implementation), when applicable. In time, local governments and the State will need to enhance their technical and administrative capacities to manage pollutants in a quantified manner.

2.1.7 Evaluation of TMDL Implementation

The evaluation of TMDL implementation involves two assessments, for which the State is generally responsible. First, verify that the pollution control practices deemed necessary to achieve the TMDL load reductions have been implemented. Second, the evaluation process should include water quality monitoring to determine whether water quality standards have been achieved. Evaluation monitoring should be conducted at the appropriate restoration stage, and over enough years to account for potential lag-times before drawing conclusions (e.g., to account for riparian reforestation maturity, or groundwater flushing).

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[5] Note that regulated stormwater, subject to an NPDES stormwater permit, is formally classified as a point source as of November 2002 (EPA, November 2002). This implies an increased level of rigor in managing this classification of stormwater-related pollutants.

It is possible that the water quality standards will continue to be exceeded even after implementing all of the pollution control practices deemed necessary to achieve the TMDL. At least five possible scenarios might lead to this circumstance.

First, the current baseline NPS pollutant load was under-estimated during the implementation planning process. This implies that more BMP implementation is needed than originally predicted. Similarly, it is possible that unknown nonpoint sources were not accounted for when estimating the baseline load.

Second, it is possible that the assumed effectiveness of the BMPs was overly optimistic so that less pollutant reduction was achieved than expected.

Third, it is possible that all of the necessary BMPs have been implemented, but that it takes time for the BMPs to have the desired effect. For example, it could take several years for nitrates to be flushed from the groundwater, or for riparian forest buffer plantings to reach maturity. Bottom sediments might also need a period of time for natural recovery after pollution inputs have been reduced.

Fourth, it is possible that the TMDL analysis over-estimated the assimilative capacity of the waterbody. That is, the waterbody can safely absorb less pollution than predicted by the TMDL analysis. A review of the TMDL analysis might be warranted.

Finally, if all of the feasible control actions have been undertaken, and the TMDL analysis is technically sound, but the water quality standards still are not being achieved, then attention must be given to the water quality standards themselves. The State conducts a review of the standards on a three-year cycle.

As this discussion suggests, the Clean Water Act lays out a systematic framework for managing our water resources. The process is designed to be "self-correcting" in the sense that, at each step of the framework, new information is generated that can be used to refine other elements of the framework. These procedures are documented according to a procedure described in the following section.

2.1.8 The Continuing Planning Process

The Clean Water Act Section 303(e) requires each State to document their water quality management operating procedures in the form of a Continuing Planning Process (CPP) document. At a minimum, the CPP must address procedures for point source permitting, management of residual waste from treatment plants, TMDL development, intergovernmental cooperation, water quality standards enhancements, and revision of the CPP itself.

By exercising the Clean Water Act framework outlined above, new insights about water quality management are gained. As the State's operating procedures are modified to reflect these new insights, revisions are made to the CPP.

2.2 Key Elements of a TMDL Analysis and Implications for TMDL Implementation

This section provides an overview of the TMDL development process. Understanding how TMDLs are developed in Maryland will help lay a foundation for thinking about implementing TMDLs. Due to the variety of impairing substances (nutrients, sediments, toxic substances, bacteria, imbalanced pH, undetermined biological impairments), and types of waterbodies for which TMDLs are developed (shallow non-tidal streams, large non-tidal rivers, small and large reservoirs, small and large tidal estuaries, and ocean waters) the specific technical aspects of the TMDL analyses can vary widely. However, all TMDL analyses include key elements required for approval by the U.S. Environmental Protection Agency (US EPA, 1999). The following subsections address each of these key elements.

2.2.1 Identify the Impairment

Identifying the impairment being addressed by the TMDL implies the following:

a. Identify the waterbody and watershed draining to the waterbody. This information helps identify the geographic extent of the impairment and sources that contribute to the impairment (See Source Assessment below).
b. Identify the impairing substance and the water quality parameter(s) that respond to different amounts of that substance. For example, a nutrient like phosphorus is a common impairing substance, and chlorophyll *a* and dissolved oxygen are the parameters that respond to different levels of nutrients.
c. Provide the data that verifies and characterizes the impairment: Geographic location and extent; temporal aspects such as frequency, duration, seasonality; degree of criterion exceedance.

TMDL implementation should focus on the specific impairment described in the TMDL, which should be consistent with the original 303(d) listing. The characterization information could help target the implementation, both geographically and temporally.

2.2.2 Identify the Water Quality Endpoint

Identify the water quality endpoint that must be achieved by the TMDL analysis. TMDLs must be developed to achieve water quality standards. Thus, the water quality endpoint used in the TMDL analysis should be consistent with the water quality criterion that is exceeded and led to the waterbody's 303(d) listing.

Chapter 8 of Maryland's Integrated Water Quality Assessment provides written documentation of the "Listing Methodologies." These describe how the water quality monitoring data are interpreted to determine if the waters meet standards. Although these data analysis procedures do not always translate precisely to the water quality modeling tools used for TMDL development, they provide the best basis for ensuring consistency between the 303(d) listing process and the TMDL development process.
http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/final_2004_303dlist.asp

For more information on water quality criteria see Section 5.2.2 "Resources."

The significance of the water quality endpoint for TMDL implementation is that it sets the threshold for evaluating success. Although this might seem fairly obvious, the subtleties of collecting and interpreting water quality data can be profound. For example, striving to achieve a water quality parameter threshold at all times or over a particular averaging period can produce vastly different results.

2.2.3 Source Assessment

A source assessment of pollutants, including natural and anthropogenic contributions, is required as part of the TMDL analysis. The maximum load must account for all sources, including atmospheric deposition and natural sources. This is because the TMDL represents the physical capacity of the waterbody to assimilate the pollutant of concern, regardless of where the pollutant originates.

The source assessment information will direct implementation to the areas contributing most to the problem. Source assessments typically must be refined during TMDL implementation planning and should be reviewed during the implementation evaluation process.

2.2.4 The TMDL

The TMDL must be clearly reported. The definition of a TMDL in Federal Regulation states that, "TMDLs can be expressed in terms of either mass per unit time [traditional load], toxicity, or other appropriate measure" (40CRF130.2). This definition is fairly flexible, including the traditional concept of pollutant loads, for example pounds of nitrogen per month. It also allows for the adoption of non-traditional TMDL methodologies, as long as such methods include sufficiently quantified "other appropriate measure(s)."

For some pollutants, different TMDL limits are set for different seasons, as discussed further below under "Critical Conditions and Seasonality." It is also noteworthy that the phrase "Daily Load" is not interpreted literally to mean mass per day. In some cases, it is more sensible to express the TMDL in terms of mass per month, or not even use mass per unit time. This understanding is clear from the broad regulatory definition cited above, and has been upheld by the courts.

The essence of a TMDL is to quantify an upper threshold on the pollutant or stressor. This establishes a rational framework for quantifying management controls to achieve the quantified TMDL. In some non-traditional TMDLs, discussed below, the quantified management actions are in-and-of-themselves the TMDL.

2.2.5 Waste Load Allocations and Load Allocations

Waste load allocations to point sources and load allocations to nonpoint sources must be identified by the TMDL analysis. That is, the TMDL, which includes natural and anthropogenic sources, must be divided among point sources and nonpoint sources as depicted in the following equation:

TMDL = Waste Load Allocations (WLA) + Load Allocations (LA) + Margin of Safety

The choice of allocations is solely the discretion of the State, provided that it is balanced in a reasonable way between source categories (See Reasonable Assurance below).

Maryland takes the view that the formal TMDL, which is approved by the US EPA, need only identify one broad aggregated WLA and one aggregated LA. That is, the TMDL need not identify separate allocations for each individual point source and nonpoint source in the study area. However, for general planning purposes, Maryland provides a "Technical Memorandum" with each TMDL report, which describes a more detailed partitioning of the TMDL among individual sources.

It is noteworthy that, as of 2002, EPA requires urban stormwater sources managed under an NPDES permit (municipal and industrial) be classified as waste load allocations (point sources) for the purpose of TMDL analyses (EPA, Nov. 2002).

NPDES permits, including those for regulated stormwater, must be consistent with TMDL allocations. Because allocations might change over time, administrative procedures for modifying allocations must be developed as part of the TMDL implementation framework. Reallocation procedures must include formal public participation.

2.2.6 Margin of Safety

A margin of safety (MOS) protective of the environment must be included in the TMDL. The MOS is intended to account for our limited knowledge of how the natural environment functions, the information available to estimate cause-and-effect relationships of pollutants in waterbodies, and other uncertainties.

The MOS may be expressed as an explicit amount of the maximum allowable pollutant load, which is set aside (not allocated to any source). Alternatively, the MOS may be expressed in terms of conservative assumptions incorporated into the analysis process.

In principle, as a greater understanding of the natural setting is gained over time, and can be factored into future refinements of TMDL analyses, the MOSs can be reduced. This would allow for more of the TMDL to be allocated to active sources.

2.2.7 Critical Conditions and Seasonality

Critical conditions and seasonality must be considered when establishing TMDLs and allocations. For example, algae growth, and the resultant bacterial decomposition that causes oxygen consumption, tends to be most pronounced during summer months. During this season there is more sunlight to promote photosynthesis and warmer water in which bacteria that consume dead algae are more active. It is also during this season that stream flows tend to be lower, resulting in less dilution of nutrient loads from waste water treatment plants. In recognition of these natural, seasonal phenomena, TMDL analyses often identify a number of thresholds that differ according to season.

For traditional point sources, the seasonality considerations of TMDL analyses often determine the maximum treatment technology, and plant operations requirements (including spray irrigation, oxygenation, etc.) that must be adopted by the plant. Because of inter-annual variability in precipitation, nonpoint source controls are usually accounted for on an average annual basis. In some natural settings, living resource life-cycles are particularly vulnerable during certain times, such as spawning seasons. TMDLs are intended to ensure that the timing of human activities, such as dredging and herbicide applications, does not conflict with these critical periods.

2.2.8 Reasonable Assurance of Implementation

The TMDL documentation includes a section that explains how the nonpoint source allocation will be attained. The intent is to ensure that the burden of pollution control not be shifted from the regulated point source sector to the unregulated nonpoint source sector as a means of easing the permitting process.

This section of the TMDL document provides an overview of the programs that will be used to implement the TMDL. It can be viewed as a cursory TMDL implementation plan, and should be consulted during the implementation planning process.

2.2.9 Public Participation

The TMDL development process must include a formal public review prior to submittal to the US EPA for approval.

Any significant future changes in the TMDL, for example, the significant redistribution of the allocations, necessitates a formal public review process. This ensures that stakeholders, who might have long-range plans that are dependent on expectations regarding the allocations, will be fully informed of any potential changes.

2.3 Diverse Types of TMDLs: Implications for Implementation

Understanding the TMDL is a basic prerequisite to its implementation. This section provides an overview of the variety of TMDLs developed in Maryland.

2.3.1 Diverse Types of Impairments

Recall that, for a given waterbody, a separate TMDL must be developed for each pollutant. For example, a reservoir might be impaired by both phosphorus and sedimentation. Consequently, two separate TMDLs would be needed for that reservoir. As indicated below in Figure 1, the State waters are impaired by a wide variety of pollutants in addition to the special case of impairments reflected by low indices of biological integrity (biological impairments).

In addition, a wide variety of different types of waterbodies are affected including: tidal rivers, tidal estuaries, non-tidal streams and rivers, various segments of the Chesapeake Bay, the coastal bays, and reservoirs of varying sizes. Furthermore, impairments can be expressed in the water itself, the physical habitat, the bottom sediments, or as bioaccumulated toxins in fish tissues.

In some cases, impairments exist long after the human activities that generated a particular pollutant have stopped. For example, bottom sediments and fish tissue can remain contaminated by toxic substances even when no new loads of that substance are entering the waterbody. This situation is commonly called a “legacy pollution” type of impairment.

Legacy pollution impairments pose a unique set of challenges. Because there are no active sources to “turn off,” achieving pollutant reductions takes on a different meaning. Reductions can be achieved in two broad ways, either by allowing natural attenuation to reduce the pollutant over time or by conducting a cleanup process. The cleanup option is often complicated. In some cases, small amounts of toxic substances are spread over large areas, challenging the concept of a traditional cleanup. In other cases, there are concerns that stirring up bottom sediments during a cleanup process could create worse problems. Additionally, if large volumes of material are accumulated in a cleanup, that material must be treated or disposed of, which can present another host of environmental and social challenges. TMDL implementation for legacy impairments also implies that new sources of the pollutant cannot be offset easily.

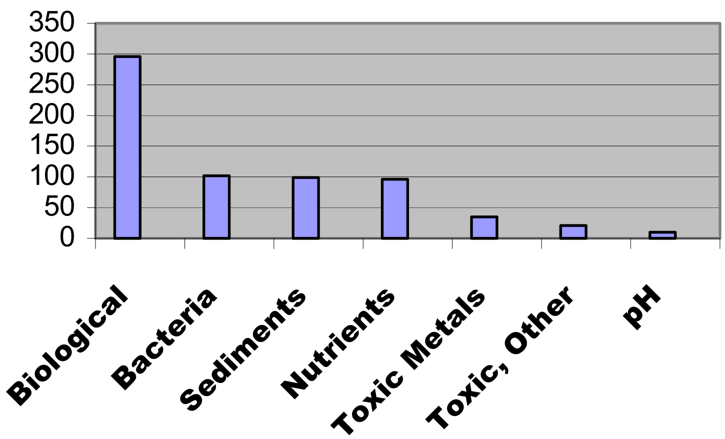

Figure 1 Types of Impairments Identified Maryland’s 303(d) List as of 2004

The special case of legacy impairments suggests that different pollutant sources can affect the way in which a TMDL analysis and TMDL implementation is conducted. Mercury impairments in lakes, expressed by elevated concentrations of methylmercury in fish tissue, represent another example. Although a lake has one assimilative capacity for mercury (the TMDL for that lake) the method used to derive the TMDL would probably differ if atmospheric deposition was not the predominant source. Similarly, the means of implementing the TMDL would differ significantly depending on the kinds of sources that need to be controlled.

In summary, the approach to TMDL implementation can vary greatly depending on the type of pollutant or stressor, the waterbody type and the source of the pollutant. This is elaborated upon in the following subsections, which address traditional TMDLs and non-traditional TMDLs.

2.3.2 Traditional TMDLs

Recall from above, federal regulation states that, "TMDLs can be expressed in terms of either mass per unit time, toxicity, or other appropriate measure" (40CRF130.2). TMDLs expressed as a "mass per unit time," or "load" represent the traditional concept of a TMDL.

TMDLs for nutrients are expressed in the traditional manner, that is, in terms of loads. Because of Maryland's long involvement in efforts to restore the Chesapeake Bay, significant attention has been devoted to nutrient impairments in tidal waterbodies. Given the prominence of the issue and technical experience gained over the years, Maryland's initial TMDLs focused on nutrients. Consequently this guidance document focuses on nutrient impairments in tidal waters.

Some toxic substances can be addressed in traditional terms of loads, provided they do not bioaccumulate or accumulate in the bottom sediments. Mercury in reservoirs, for example, is expressed in loads, although the primary source is atmospheric deposition. Biochemical oxygen demand (BOD), which is a measure of organic matter, can also be addressed in terms of loads. TMDLs that address excessive reservoir sedimentation are expressed in terms of loads. The units might vary, with toxic substances often being expressed in small units of mass and short time periods, BOD being expressed in more intermediate terms, and sediments being expressed in large units of mass and longer time periods.

2.3.3 Non-Traditional TMDLs

TMDLs expressed in terms of "toxicity or other appropriate measure" can be called "non-traditional" TMDLs. Although Maryland has not developed many of these, the concept is worth noting, because as we begin to address biological degradation, non-traditional TMDLs will likely become increasingly important.

The potential types of non-traditional TMDLs are limited only by the creativity of TMDL development practitioners. The primary criterion for any TMDL is that the stressor must be expressed in a quantitative manner, and linked by cause-and-effect to the relevant water quality standard cited in the 303(d) listing.

In one case where chlordane, a banned termite pesticide was identified as the pollutant, the 303(d) impairment was expressed in terms of excessive fish tissue concentrations. Although some trace amounts might continue to come from the non-tidal streams, data indicated that the dominant source of chlordane was bottom sediments in the receiving waterbodies (reservoir and tidal estuary). Historic sampling seemed to indicate that chlordane concentrations in bottom sediments were decreasing, suggesting that this was a legacy pollution problem.

The working theory was that fish tissue concentrations were predicted to decrease as the waterbodies recovered naturally over time. Because the dominant source was the bottom sediments, a flux and load from the bottom could have been computed; however, the essential limit needed to prevent fish tissue accumulation was a threshold on the concentration in the water column. Although the load from the bottom is a function of bottom area, and could be computed, the water column concentration remains the same, regardless of whether the bottom area was one square meter or one square mile. In other words, the concentration, and not the load from the bottom sediment, was what determined the fish tissue concentration.

Based on this logic, and several other factors, an agreement was reached with EPA to express the TMDL in terms of "toxicity." That is, the TMDL is expressed as water column concentration predicted to be protective of the fish tissue bioaccumulation. The other factors included the recognition that the TMDL was addressing a substance no longer registered for use (legacy pollution), and that preliminary data indicated on-going natural recovery of bottom sediments (chlordane concentrations were decreasing). To institutionalize accountability, EPA's approval of the TMDL was conditioned upon the State committing to 1) conduct additional fish tissue monitoring to verify that natural recovery was occurring, and 2) to conduct source assessment monitoring if the fish tissue monitoring did not verify that chlordane concentrations in fish tissue were decreasing.

The previous example regarding chlordane is instructive. It demonstrates that a non-traditional TMDL can be developed and approved by EPA without complex modeling, provided that a commitment is made to an implementation-oriented adaptive approach. That is, highly detailed predictive modeling was exchanged for follow-up monitoring, and a commitment to iterative assessment and remediation steps. This is the essence of "adaptive management," which tends to be a hallmark of most non-traditional TMDLs.

Several other states have grappled with addressing biological impairments in non-tidal streams for which the stressor or impairing substance is not clear. Because the physical processes of a stream system are so complex, the prospect of successfully developing predictive models, or even statistical models based on empirical data, is remote. Such modeling is also very time-consuming and expensive. In such cases, some states have turned to adaptive management approaches in which the TMDL development process is tightly linked to the TMDL implementation process. That is, trial-and-error TMDL implementation is guided by a non-traditional TMDL expressed as a set of quantified target values for in-stream and upland "indicators." Relationships between these indicators represent the necessary linkage between the stress (source) and the water quality standard (receptor), which is a basic requirement of any TMDL analysis. With this in mind, consider the following simplified illustrative example regarding a biological impairment in non-tidal streams.

Consider a stream that fails to meet indices of biological integrity (IBI) for both benthic macroinvertebrates and fish. A field assessment suggests that the stressors are excessive hydrological energy due to land surface modification of the uplands; denuded riparian vegetation; sediment infill of pools that also submerges boulders, which previously dissipated stream energy; channel straightening; levy construction with resultant reduction in flood plain area; and erosive stream banks.

Table 2-1

Illustrative Example of Multiple-Indicator Non-Traditional TMDL

Non-Traditional TMDL Indicators	Numeric Target
Stream Energy Reduction: Combination of the following	35% Total Reduction[a]
Upland Controls	Maximum watershed-wide effective imperviousness of 25% Maximum sub-basin effective imperviousness of 35%
Channel Sinuosity	0% - 30% Increase
Flood Plain Reclamation	0 – 40 acres
Stream Debris	0% - 15% Increase in Bottom Roughness Coefficient
Pool Reestablishment in mainstem	mean depth > 2m at low flow
Bank Stability	No more than 10% erosive banks
Riparian Buffers	At least 75% of stream miles buffered

a. Expressed in terms of standard measures of mean and peak stream energies.

A non-traditional TMDL could be expressed in terms of quantified multiple-indicators representing remediation for each of the "stressors" noted above. Specific quantified targets for each stressor can be determined by a combination of engineering calculations, paired watershed analyses, and simple statistical relationships. These computations would provide a causal linkage between the stressor and the water quality endpoint of acceptable fish and benthic IBIs. The linkage need not be precise, provided that a commitment exists to take implementation steps, monitor the results, and refine those actions as needed. The non-traditional TMDL result might appear as in Table 1.

2.3.4 Near-field and Far-field Impairments

The final topic covered in this section is the distinction between near-field impairments, in which the source or cause is close to the impact, and far-field impairments, in which larger watersheds contribute to downstream impacts. The classic near-field impairment is physical habitat impairment of a non-tidal stream caused by excessive hydraulic energy associated with land cover modification. The classic far-field impairment is eutrophication expressed as algae blooms and low dissolved oxygen caused by nutrients draining to a tidal estuary from a large watershed. Near-field impairments are closer to the source or cause of the impairment, and tend to be more geographically localized. The opposite is true for far-field impairments. It is worth noting that some pollutants, for instance BOD, act at a somewhat intermediate range.

These distinctions are essential to an understanding of TMDL implementation and to avoid confusion. The phrase "TMDL implementation" can mean very different things depending on the type of impairment. Implementation planning for near-field impairments is likely to take the form of a localized stream restoration project, whereas planning for a far-field impairment is likely to take the form of identifying best management practices (BMPs) in a fairly large watershed.

Note, however, that BMPs in the far-field case can be targeted toward hot-spot sources, and eroding streams are one type of hot-spot source. An example would be a farmer who implements stream fencing and off-stream watering for livestock. The BMP implementation would reduce degradation from livestock in the stream, allow for riparian buffer re-establishment, and reduce the nutrients and bacteria flowing downstream that may impact waters many miles away. Clearly there is a relationship between the near-field and far-field impairments, which can be exploited to efficiently address two separate and distinct impairments; we can eliminate a near-field impairment while at the same time making progress on reducing loads that contribute to the downstream far-field impairment.

Another distinction is worth noting: Consider the far-field case when a new pollutant source is introduced. It is possible to offset that new load by making a reduction at a location in the watershed far away from the new source. In the near-field case, mitigation of a new source typically needs to take place close to it, which limits the options.

Given that TMDLs have not yet been developed for near-field cases, but have been for far-field cases (e.g., nutrients), this guidance document will focus on the latter. Nevertheless, as a general matter, local jurisdictions are advised to follow the Guidance for setting development standards under a sensitive areas element for the comprehensive plan (MDP 1993). That is, in areas that meet federal and State water quality standards, developers should strive to make post-development water quality as good as pre-development quality. For development where standards are not attained (impaired waters) post-development water quality should be improved over pre-development levels.